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(71) Applicant: BREED AUTOMOTIVE TECHNOLOGY, INC. [US/US]; P.O. Box 33050, Lakeland, FL 33807-3050 (US).

(72) Inventors: TREVILLYAN, Dennis, A.; 2303 Ashley Court, Plant City, FL 33566 (US). YENCHO, Jon, A.; 1828 Stella Court, Lakeland, FL 33813 (US). WARREN, Donald, E.; 5675 Bloomfield Blvd., Lakeland, FL 33810 (US).

(74) Agents: DRAYER, Lonnie, R.; Breed Automotive Technology, Inc., P.O. Box 33050, Lakeland, FL 33807-3050 et al. (US).

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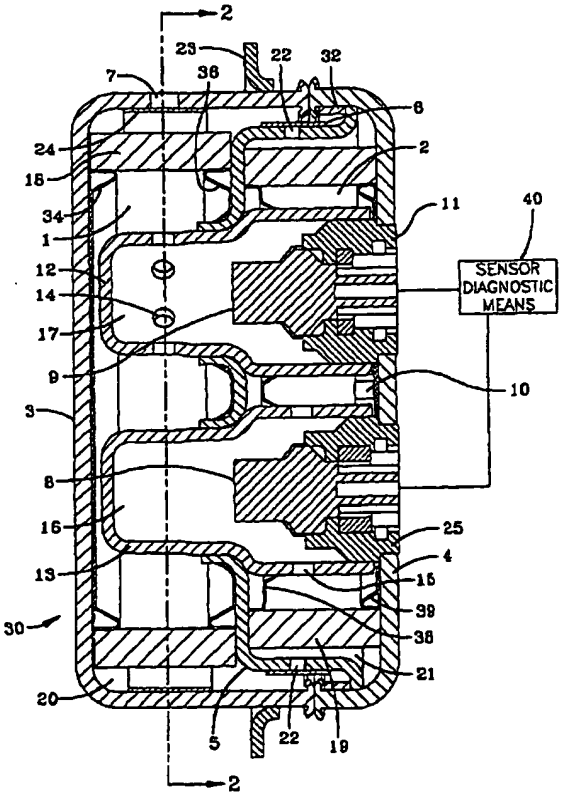
(54) Title: DUAL STAGE AIRBAG INFLATOR



(57) Abstract: A dual stage airbag inflator (30) has primary and secondary combustion chambers (1, 2) and a common gas exiting port (7) for controlling the combustion pressure in both combustion chambers. This inflator can inflate an airbag at different rates dependent on the firing sequence used. The low output performance level occurs when only the primary stage is deployed. Simultaneous firing of both the primary and secondary stages constitutes the upper performance limits, while staging results from deployment of the primary stage and some time later deployment of the secondary stage. The staging provides a means to supply inflation gas in a variable rate fashion.

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DUAL STAGE AIRBAG INFLATOR

The present invention relates to gas generators or inflators, for inflating vehicle restraint cushions, commonly known as airbags.

The present invention relates to an apparatus used to stage the inflation of an airbag in a vehicle occupant restraint system. This invention, a dual stage pyrotechnic inflator, is a two-stage gas generator used to provide a variable gas output so that the rate of airbag inflation can be controlled. Controlling the rate of gas generation and thereby the rate of rise of pressure within the airbag provides better protection for a wider range of vehicle occupants while minimizing the risk of injury resulting from the airbag deployment.

The present invention supplies gas used to fill an airbag in either a single stage or multistage manner. This is accomplished through the use of two combustion chambers in isolation, containing gas generating chemicals. Deployment modes may involve deployment of both stages at once or the primary followed by the secondary at some later time to provide the desired gas delivery event.

The problems left unsolved by the prior art are overcome by the invention set forth in appended claim 1.

Controlled inflation of an airbag as taught in US 5 558 367 employs a hybrid inflator containing an inflating fluid and two igniters. The fluid is released by activation of the first igniter. A second igniter is used to ignite combustible material for the purpose of increasing the temperature and pressure of

the contained fluid. US 5 582 428, US 5 630 619 and US 5 709 406 disclose the use of hybrid technology to address the staging problem. The present invention is not a hybrid inflator.

US 5 221 109 incorporates into the gas generator, a venting mechanism used to control gas output. US 5 346 254 discloses a single combustion chamber inflator design, which employs dual output igniter. The first stage of the igniter provides the ignition impulse required to ignite the gas generating chemicals and some point in time later the second stage of the igniter is fired, cracking the gas generating chemical thereby increasing the surface area available for combustion.

US 5 368 329 and US 5 398 966 disclose an elongated inflator housing, containing gas-generating wafers spaced along the length of the tube, containing two igniters. The primary igniter provides the ignition source to ignite the gas generating chemicals and the second igniter is used to shatter the wafer when fired at a latter time. Shattering of the gas generating chemical wafer increases burning surface area and thereby the mass generation rate of gas. The present invention does not employ generant shattering technology.

US 5 564 743 discloses a multiple stage airbag inflator system wherein the inflator housing contains two separated chambers, each containing gas generating material and an ignition system. The wall that separates the two chambers has a frangible section designed to rupture in response to a predetermined level of gas pressure in one of the chambers, thus providing fluid communication between the chambers.

US 5 460 405 discloses an apparatus containing a controller and a collision and position sensor for controlling the actuation of the first and second fluid source required to inflate the airbag.

US 5 400 487 discloses a system whereby multiple individual gas generators are used to generate the desired airbag inflation rate. No mention is made of the use of a single staged inflator. US 5 839 754 discloses a multi-chambered gas generator and a single ignition source used to ignite the gas generating chemicals in the primary chamber. The gas generating chemicals housed in the primary combustion chamber in the primary chamber serves as an ignition source for the gas generating chemicals housed in the secondary chamber by forcing hot burning gas through bores and into the secondary chambers.

Brief Description of the Drawings

Fig. 1 shows a side cross-sectional view of an inflator constructed in accordance with the instant invention.

Fig. 2 is cross-sectional view of an inflator in accordance with the invention taken along line 2-2 of Fig. 1.

Detailed Description of the Invention

Referring to Fig. 1, an embodiment of an inflator constructed in accordance with this invention is generally designated by reference number 30. The inflator 30 has two discreet chambers: a primary combustion chamber 1 and a secondary combustion chamber 2. Primary stage gas generator activation occurs when a first quantity of gas generating chemicals (not shown for the purpose of clarity) housed in the primary combustion chamber 1 is ignited and gas is produced. Likewise, secondary stage gas generator activation occurs when a second quantity of gas generating chemicals (not shown for purpose of clarity) in the secondary combustion chamber 2 is ignited and begins to produce gas. A plurality of primary gas exit ports 7 in the upper housing 3 control the pressure development in both the primary 1 and secondary 2 combustion chambers. In an event requiring a low output deployment only the gas generating chemicals housed in the primary combustion chamber 1 is ignited. When a high output deployment is required the gas generating chemicals in both the primary and secondary combustion chambers will be ignited simultaneously.

Staging at intermediate levels will involve ignition of the gas generating chemicals in the primary combustion chamber followed by ignition of the gas generating chemicals in the secondary combustion chamber gas at some point later in the event. Staging thereby controls rate of generation of inflating gases going into the airbag and thereby the inflation rates. In a preferred embodiment the primary chamber 1

contains from 50% to 80% of the total gas generant load, and the secondary chamber 2 contains from 20% to 50% of the total gas generant load.

The inflator 30 has two chambers housing gas generating chemicals. A cup shaped upper housing 3 and a cup shaped lower housing 4 form the primary combustion chamber 1. Referring to Figs. 1 and 2, the upper housing 3 contains a plurality of primary gas exit ports 7. The primary gas exit ports may be, but are not limited to, a single diameter. A primary closure 24, such as a thin metallic foil 24 adhesively-bonded to the upper housing 3 or a plug over the port, serves as a hermetic seal. Two circular holes are located in the lower housing 4 to accept the two igniter retainers 11, 25. The upper housing 3 and lower housing 4 are configured in such a manner as to be welded together. A flange 23 is attached to the upper housing 3 by welding or crimping, although it could also be attached or consolidated into the lower housing 4.

The volume defined by the interior of the upper housing 3 and the lower housing 4 is separated into two chambers by a divider plate 5. The divider plate 5 is cup shaped and consists of a substantially circular end plate and an outer tubular wall containing a plurality of secondary gas exit ports 22. The secondary gas exit ports 22 are of circular holes through the divider plate 5 and may be, but are not limited to, a single diameter. The secondary gas exit ports 22 are closed by a secondary closure 6, such as thin metallic foil adhesively bonded over the gas exit ports. The secondary closure 6 prevents the gasses produced by combustion in the primary combustion

chamber 1 from entering the secondary combustion chamber 2 during a low output deployment and subsequent ignition of the gas generating chemicals housed therein. The outer tubular wall of the divider plate 5 is joined to the lower housing 4 and is retained by a close fit with a retaining ring 32 positioned between the lower housing and the divider plate.

The primary combustion chamber enhancer tube 12 and the secondary combustion chamber enhancer tube 13 are inserted into the substantially circular end plate of the divider plate 5 and retained in place by a press fit and / or weld. The primary enhancer tube 12 is positioned in such a manner as to place the primary enhancer tube exit ports 14 in the primary chamber 1. The secondary enhancer tube exit ports 15 are positioned in such a manner as to place the secondary enhancer ports 15 in the secondary combustion chamber 2. The primary enhancer tube 12 and the secondary enhancer tube 13 comprise a substantially circular end plate and an outer tubular wall with a plurality of enhancer ports 14, 15. The enhancer ports are circular and distributed circumferentially around the outer tubular walls of the enhancer tubes 12, 13. The enhancer ports may be, but are not limited to, a single diameter. The primary combustion chamber igniter retainer 11 is welded into the lower housing 4 and protrudes into the open end of the primary enhancer tube 12. A press fit is utilized to insure a gas tight seal between the primary combustion chamber enhancer tube 12 and the primary combustion chamber igniter retainer 11. Similar assembly is required for the secondary combustion chamber enhancer tube 13 and

the secondary combustion chamber igniter retainer 25. The primary enhancer 17 (not shown for reasons of clarity) housed inside the primary igniter tube 12 comprises of an ignition material in the form of powder, granules and / or pellets. A primary igniter means 9 ignites the primary enhancer 17 after receiving an electrical signal from the sensor diagnostic means 40. The secondary combustion chamber igniter retainer 25, secondary igniter 8, and the secondary enhancer 16 (not shown for reasons of clarity) are similar in design and function to their primary stage counterparts. The primary filter 18 cools and filters particulates from the gas stream prior to the gas leaving the inflator through the primary gas exit ports 7. The primary filter is held in place by primary filter seals 34, 36. The secondary filter 19 performs a similar function in the secondary combustion chamber 2, and is held in place with secondary filter seals 38, 39.

In operation the inflator functions after receiving an electric signal from sensor diagnostic means, which determines the type of airbag inflation required for optimal vehicle occupant protection depending on the severity of a crash and the occupant position and size. The airbag inflation will begin with the deployment of the low output mode of the inflator or only the primary stage. The low output mode or primary stage functions when the primary igniter means 9 receives an electric signal from the sensor diagnostic means 40. When the igniter means 9 receives the signal, and activation occurs, ignition of the primary enhancer 17 results. The burning primary enhancer 17 produces hot gas and particles,

which are expelled from the primary enhancer tube 12 through the primary enhancer ports 14 and into the primary combustion chamber 1 igniting the first quantity of gas generating chemicals housed therein. Once the first quantity of gas generating chemicals is ignited, gas flows through the primary filter 18 and into a first gas collection plenum 20. When the pressure inside the primary combustion chamber reaches a predetermined level the primary closure 24 ruptures allowing the gas to flow through the primary exhaust ports 7 and into the airbag. The secondary closure 6 prevents sympathetic ignition of secondary stage by preventing the hot gasses from entering the secondary combustion chamber 2 through secondary gas ports 22 and igniting the gas generating chemicals housed therein.

The high output mode requires that both the primary 9 and secondary igniter means 8 are activated simultaneously by sensor diagnostic means 40. The primary combustion chamber 1 would function as described above. The secondary stage occurs when the gas generating chemicals housed in the secondary combustion chamber 2 has been ignited. Function of the second stage occurs in a manner similar to the primary stage. The secondary igniter means 8 ignites the secondary enhancer 16. The burning secondary enhancer 16 produces hot gas and hot particles which are expelled from the secondary enhancer tube 13 through the secondary enhancer ports 15 and into the quantity of gas generating chemicals housed in the secondary combustion chamber 2. The gas generating chemicals housed in the secondary combustion chamber when ignited produce gas, which flows through the

secondary filter 19 and into a second gas plenum 21. As the secondary combustion chamber pressure increases the secondary closure 6 opens allowing the gas to flow through the secondary gas ports 22 and into the first gas collection plenum 20 and through the primary gas ports 7 into the airbag.

The secondary stage can be deployed simultaneously with the primary stage or the secondary stage may be delayed to some time later as determined by sensor diagnostic means 40. The function of each chamber or stage is the same in all cases. In the case of long interstage delays, the primary stage deployment may be completed prior to function of the secondary chamber. The secondary gas ports 22 are sized properly to provide for proper combustion of the gas generating chemicals housed in the secondary combustion chamber and minimal noxious effluents while limiting the gas output to an acceptable level.

In the event that the inflator 30 is exposed to fire or other sources of extreme heat the inflator 30 is designed to autoignite and function in the normal manner. An autoignition element 10 is placed in intimate thermal contact with the lower housing 4 in the secondary chamber 2. In the event of exposure to high temperatures the autoignition element 10 deploys igniting the gas generating chemicals housed in the secondary combustion chamber. The gasses produced by the gas generating chemicals flow through the secondary enhancer ports 15 and ignite the secondary enhancer 16 and secondary igniter 8. As the gasses enter the first plenum 20 they also pass through the

primary filter 18 and ignite the gas generating chemicals housed in the primary combustion chamber, primary enhancer 17 and primary igniter 9.

Claims:

1. A dual stage airbag inflator (30) comprising:

a primary combustion chamber (1) containing a first quantity of gas generating chemicals, said primary chamber having a plurality of primary gas ports (7) communicating said primary combustion chamber with said airbag;

a secondary combustion chamber (2) containing a second quantity of gas generating chemicals, said secondary combustion chamber having a plurality of secondary gas ports (22) with a secondary closure, wherein the secondary ports connect the primary and secondary combustion chambers;

a primary igniter means (9) for igniting the first quantity of gas generating chemicals;

a secondary igniter means (8) for igniting the second quantity of gas generating chemicals; and

a sensor diagnostic means connected to the primary and secondary igniter means, wherein a sensing means sends a signal to the primary and secondary igniter means to activate the primary and secondary igniter means as required.

2. The dual stage airbag inflator (30) of claim 1 further comprising a primary filter (18) located between the primary combustion chamber (1) and the primary gas ports (7); and a secondary filter (19) located between the secondary combustion chamber (2) and the secondary gas ports (22).

3. The dual stage airbag inflator (30) of claim 1 wherein the combustion chamber pressure for both the primary and secondary combustion chambers (1, 2) is controlled by the primary gas ports (7).

4. The dual stage airbag inflator (30) of claim 1 further comprising a burst foil (24) attached to the primary gas ports (7).

5. The dual stage airbag inflator (30) of claim 1 wherein the secondary closure is foil (24) over the secondary gas ports (22).

6. The dual stage airbag inflator (30) of claim 1 further comprising a first gas plenum (20) located between the primary combustion chamber (1) and the primary gas ports (7) and a second gas plenum (21) located between the secondary combustion chamber (2) and the secondary gas ports (22).

7. The dual stage airbag inflator (30) of claim 1 further comprising a primary combustion chamber enhancer tube (12) containing a primary enhancer (17), the primary enhancer tube having a plurality of primary enhancer ports positioned in the primary combustion chamber (1), wherein the primary igniter means ignites the primary enhancer which produces hot gas that is expelled through the primary enhancer ports igniting the first quantity of gas generating chemicals; and a secondary combustion chamber enhancer tube (13) containing a secondary enhancer (16), the secondary enhancer tube having a plurality of secondary enhancer ports positioned in the secondary

combustion chamber (2) , wherein the secondary igniter means (8) ignites the secondary enhancer which produces hot gas that is expelled through the secondary enhancer ports igniting the second quantity of gas generating chemicals.

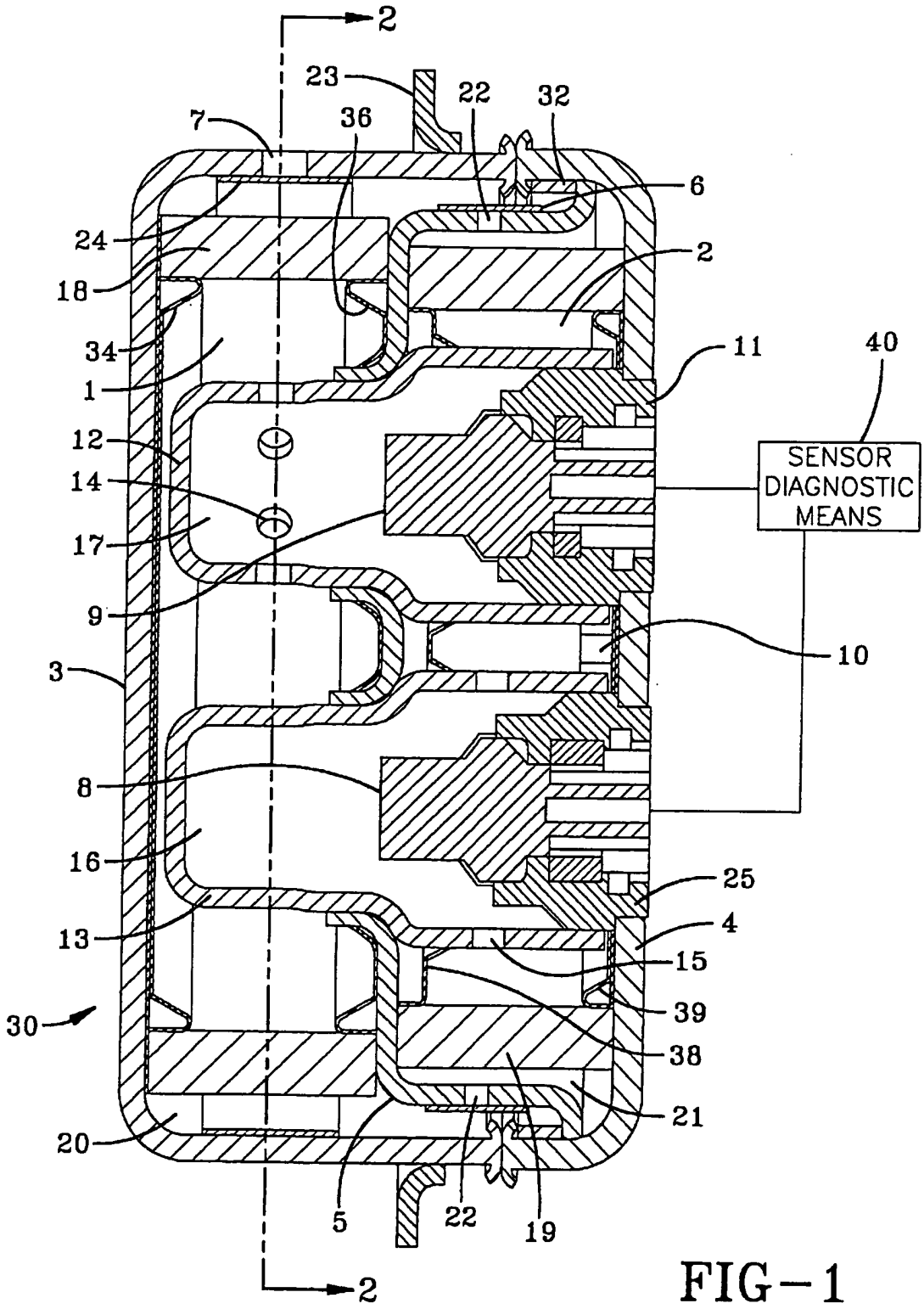
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FIG-1

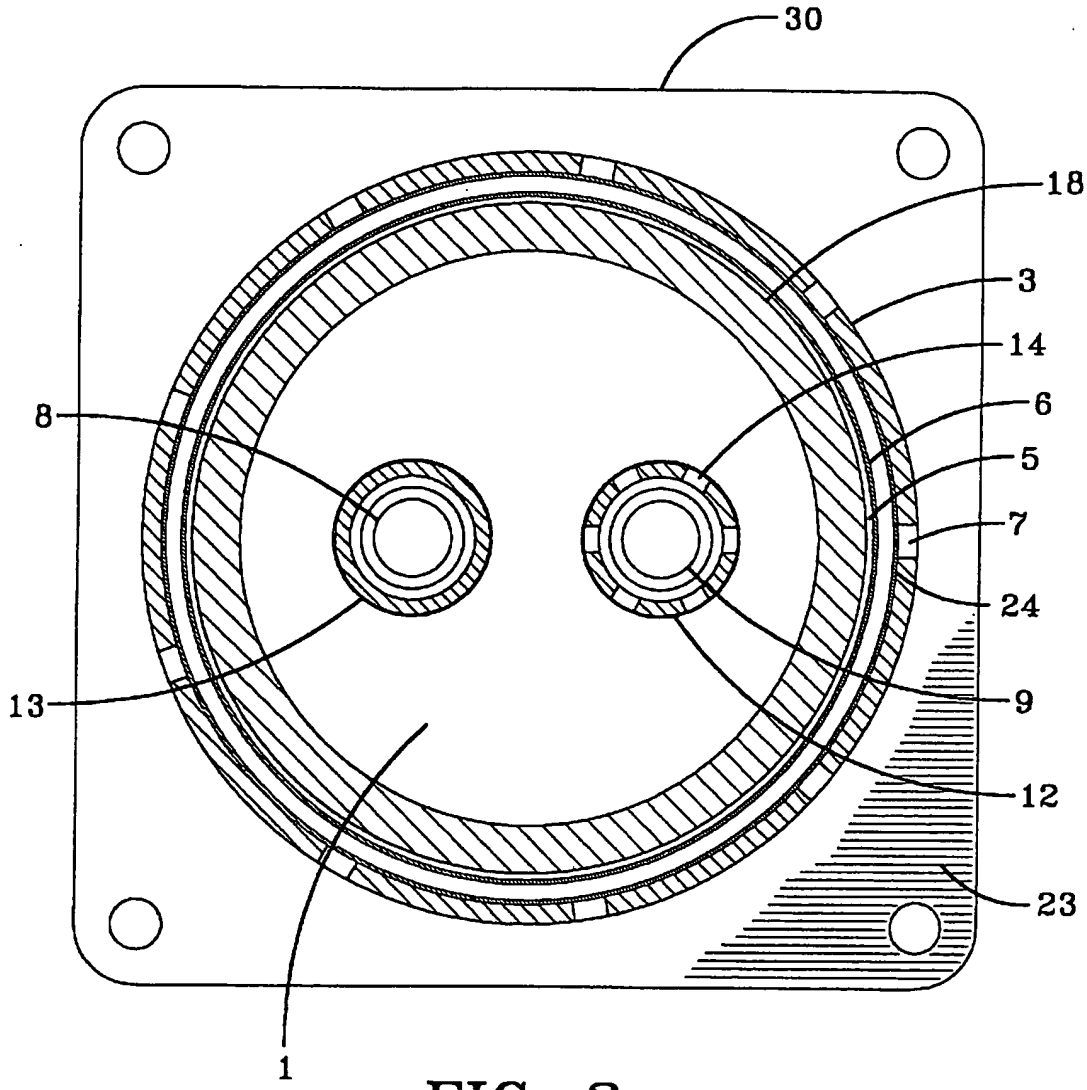

FIG-2

INTERNATIONAL SEARCH REPORT

Int. tional Application No
PCT/US 00/12677

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60R21/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 196 20 758 A (TEMIC BAYERN CHEM AIRBAG GMBH) 27 November 1997 (1997-11-27) column 6, last paragraph -column 7, line 27; figure 1	1,2,6
X	US 5 564 743 A (MARCHANT BRENT R) 15 October 1996 (1996-10-15) cited in the application	1
A	column 1, paragraph 1 column 3, line 43 -column 5, line 55; figures 1-3	2
P,X	DE 198 22 654 A (DYNAMIT NOBEL AG) 25 November 1999 (1999-11-25) the whole document	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 September 2000	14/09/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Petersson, M

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INTERNATIONAL SEARCH REPORT

Int. ional Application No
PCT/US 00/12677

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 582 428 A (BUCHANAN ERIC S ET AL) 10 December 1996 (1996-12-10) cited in the application the whole document	3-6

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. ional Application No
PCT/US 00/12677

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19620758 A	27-11-1997	NONE	
US 5564743 A	15-10-1996	EP 0733519 A	25-09-1996
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US 5582428 A	10-12-1996	EP 0792775 A	03-09-1997
		US 5630619 A	20-05-1997